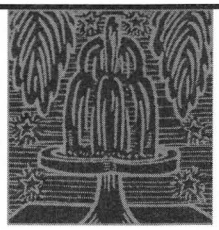

Behavioral Approaches to Creativity

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Contingency of Reinforcement The relationship between behavior, its consequences, and its antecedents.

Generalization The spread of effect from one stimulus to another.

Generativity Theory A formal theory of the creative process that suggests that new behavior is the result of an orderly competition among previously established behaviors.

Modeling Demonstrating a behavior to someone you want to engage in that behavior.

Operant Behavior Behavior that is modifiable by its consequences.

Prompt A verbal or physical signal to engage in a particular behavior.

Reinforcement The delivery of a reinforcer.

Reinforcer A consequence of behavior that strengthens that behavior.

Self-Management The use of behavior modification techniques to change one's own behavior.

Stimulus Equivalence The spontaneous emergence of a perceived relationship between stimuli.

A BEHAVIORAL APPROACH to creativity focuses on the relationship between an individual's behavior and events in and properties of the individual's environment. This approach employs techniques such as reinforcement, prompting, modeling, and environmental manipulation to enhance creativity. It differs from cognitive approaches in its avoidance of mentalistic language and construct-based models.

I. BACKGROUND

Behavioral psychology has its origins in the work of Ivan Pavlov (1849–1936), Edward L. Thorndike (1874–1949), John B. Watson (1878–1958), Clark L. Hull (1884–1952), B. F. Skinner (1904–1990), and others. The modern discipline is dominated by Skinner's work, which focuses on *operant behavior*—behavior that is modifiable by its consequences. Behavioral psychologists have typically studied the observable behavior of both animals and people as well as techniques for strengthening or weakening behavior.

Generally speaking, creativity has been of little concern to researchers and practitioners working in the behavioral tradition. Skinner himself wrote about it rarely and never conducted research on creativity per se. As both inventor and author, Skinner would probably be

considered a highly creative person, but as a scientist he seemed unconcerned with the processes that might account for his creativity. In his later writings, such as *The Technology of Teaching*, published in 1968, and various essays he wrote for students, he offered advice about how to promote creativity, but his advice was informal and was based on neither research nor theory.

Behavioral psychologists have avoided studying creativity for three reasons: First, the concept of creativity suggests that people initiate action, whereas Skinner and other early behaviorists believed that all behavior is determined by a person's genetic endowment and environmental history with no real initiative taking place. Second, behavioral psychologists have generally preferred to work from the simple to the complex, basing their terms and concepts on animal studies rather than borrowing terms from the vernacular. Consequently, terms like *creativity* (along with *intelligence, love, humor,* and so on) are viewed with suspicion. Third, behavioral psychology tends to be practical and goal directed, focusing on methods for modifying existing behavior in specified ways rather than on allowing behavior to vary unpredictably.

Nevertheless, beginning in the late 1960s, a few behavioral psychologists began to apply behavioral methods and concepts to the study of creativity. Especially notable are a series of studies by Elizabeth Goetz and her colleagues, which showed that reinforcement could be used to promote creativity in preschool children. By 1985, research studies by Goetz and others prompted a critical review by Andrew S. Winston and Joanne E. Baker of 20 "behavior analytic studies of creativity." The review concluded that behavioral techniques appear to increase creative responding, but it also noted a number of difficulties: possible confounds between instructions and reinforcement contingencies, failure to assess the value or usefulness of creative products, and little or no follow-up to determine whether creativity persisted after training.

Another behavioral model of creativity was proposed by D. H. Wells in 1986. Wells adopted a widely used definition of creativity, namely that it refers to behavior that is both novel and useful, and suggested that one's creative ability is determined by a lifetime of reinforcement and punishment of such behavior. Thus, according to Wells, creativity can be encouraged by the consistent reinforcement of behavior that is both novel and useful. [*See* NOVELTY.]

Finally, studies by Robert Epstein beginning in the late 1970s led to the development of Generativity Theory, a formal theory of creative behavior that can predict creative performances moment to moment in time in laboratory settings in both animals and humans. According to Generativity Theory, creative behavior is the result of interconnections among previously established behaviors, and research has shown that the process of interconnection is orderly and predictable. Generativity research has led in recent years to new techniques for training creativity and to assessment tools for measuring competencies related to creative performance. [*See* GENERATIVITY THEORY.]

Although behavioral psychologists have made some headway in the study of creativity, the behavioral perspective is not without its critics. Robert J. Sternberg, Paul G. Muscari, and others have expressed concerns that a scientific analysis of creativity might trivialize or depersonalize the concept. Sternberg cites studies by Janet Metcalfe, which suggest that insightful problem solving is qualitatively different from other types of problem solving, as evidence that creativity cannot yet be understood in rigorous terms. Others, such as Peter Trower, fault behavioral psychology for ignoring both cognitive and volitional aspects of behavior. But the most substantive controversy about the behavioral approach to creativity has focused on an empirical issue: Can reinforcement be used to enhance creativity, or might it actually be detrimental to creativity?

II. REINFORCEMENT AS A TOOL FOR PROMOTING CREATIVITY

In 1969 Karen Pryor and colleagues discovered that a porpoise that was receiving food for displaying a new behavior at a daily animal show began spontaneously emitting complex and unusual behaviors. Many of these behaviors had never been seen before in this or in any other porpoise at the park. With a second porpoise novel behaviors were reinforced with food in daily training sessions. By the 16th session the porpoise began emitting multiple new behaviors during each session. In the final sessions (31 and 32) the ani-

mal immediately produced a new behavior at the onset of the session and never replicated an old behavior. Moreover, both porpoises showed increased tendencies to display unusual behavior in response to everyday situations.

Elizabeth Goetz, Donald Baer, and their colleagues carried out a number of studies showing that reinforcement can be used to promote creativity in preschool children. In 1971 Goetz and Baer used block constructions as a medium for the observation of the development of new behavior. A baseline level of creativity was established for each of three 4-year-old girls by scoring the number of forms contained in her block constructions. Following this the girls received verbal praise, sometimes containing a description of what was of interest in their constructions, for each new block form that appeared during the course of a session. This was followed by sessions in which the children received praise each time a block form was repeated. Finally, the children were again praised for the production of new block construction forms. Block constructions were scored for form diversity (the number of different forms produced per session) and new forms (the number of forms per session that had not been produced in any previous session). Goetz and Baer found that form diversity scores were greater when the children were praised each time a different form appeared and less when the children were not praised or when praise was given for replicating previous forms. New forms emerged almost exclusively during sessions in which the children were praised. The children also spent longer periods of time at the block-building task when they were praised.

In 1972 Elizabeth Goetz and Mary Salmonson sought to determine whether descriptive praise is more effective than general praise in promoting creativity in children. Creativity was assessed by scoring the easel paintings of three preschool girls for form diversity and new forms. A list of 25 different objectively defined forms was used for scoring. The authors found that the greatest increases in form diversity occurred when the girls received descriptive praise rather than general praise. A later study showed that form diversity could be maintained for at least ten weeks after praise was discontinued.

A 1977 report by Goetz and colleagues explored whether reinforcing creative behavior in one activity would increase creativity in other activities. In the first of two studies, two subjects—a 5-year-old boy and a 3-year-old girl—received descriptive praise for producing new and diverse forms in easel paintings. The experiment consisted of a baseline-treatment–reversal-treatment design. Painting sessions were followed, either immediately or on the next day, by block-building sessions. No praise was given for form diversity or new forms produced during block building. In general, both form diversity and new forms increased in painting in response to praise. A pattern of increases in form diversity in block constructions appeared, which paralleled the increases produced by praise in paintings, but the increases were much less pronounced in the block-building task than in the painting task. Form diversity in both tasks dropped during the reversal phase of the experiment. New forms did not appear in the block constructions. In other words, there appeared to be some generalization of form diversity but not of new forms.

In the second study, three male preschool children received tokens (redeemable for a toy at the end of the session) and descriptive praise for producing form diversity and new forms in felt-tip-pen drawings. One of the three boys also received tokens and praise for form diversity and new forms produced in Lego constructions. All drawing sessions were followed by painting sessions. Form diversity and new forms were tracked for all of these activities. All of the children displayed an increase in form diversity in their felt-tip-pen drawings as a result of reinforcement. Two of the three children also displayed some subsequent increases in form diversity in their paintings. These two children displayed maintenance of this of diversity in their paintings and drawings at a 2-month follow-up. No generalization of form diversity was observed from the drawing to the building tasks. The child who had received diversity training in Lego construction did not generalize this behavior to block building. In other words, for two of three boys, creative tendencies generalized to a similar activity but not to a dissimilar one. A study of tool use in preschool children found a similar generalization pattern.

In all of the studies mentioned thus far, praise was given every time the subject displayed a behavior that was targeted for increase—a high labor-intensive

training regimen. In subsequent research Goetz found that relatively low rates of reinforcement can promote creative behavior, which suggests that the creativity of children that occurs during free play in classroom settings may result from low rates of reinforcement of creative behavior.

Goetz summarized the results of these and other reinforcement studies in 1982 and offered seven tentative conclusions: (a) Various types of contingent praise can be used to reinforce novel behavior. (b) Generalization of creative behavior occurs in some instances. (c) Minimal amounts of reinforcement can be used to increase novel behavior. (d) Verbal prompts can be combined with reinforcement to promote creative behavior. (e) Creativity is limited by neither materials nor time. (f) Maintenance of creative behavior can occur following training. (g) Creativity can be coded for the purpose of training and research.

Reinforcement has also been studied as a means to promote creativity in the use of language. A variety of studies have shown that originality and creativity in writing can be improved using behavioral techniques. Writing becomes more creative when certain aspects of writing—such as the use of action verbs—are reinforced. Unfortunately, in many of the studies reinforcement is often combined with instructions or modeling, which makes it difficult to isolate the effect of reinforcement alone.

The effect of modeling and reinforcement on the creation of generative sentences was studied in two experiments conducted by George T. Endo and Howard N. Sloane, Jr., in 1982. In the first study four children were presented with nouns with which they were to fabricate sentences. An adult then made statements to the children in which nonhuman nouns were personified, such as "Glasses are afraid of stones." The models received general praise and tokens for their statements. Following each modeled statement, the children were given the opportunity to make a different sentence with the same noun. If the children were able to do so they received praise and tokens. In a second modeling session, nonpersonified sentences were modeled and reinforced. During the first and second sessions of modeling, probes were conducted in which models made incorrect sentences and the children were given the opportunity to correct them. Personification, which was absent in the children's sentences at baseline, developed and increased quickly in response to modeling and reinforcement.

In a second experiment, children were given nouns different than those used by the models, and the models presented five sentences to the children before the children composed their own sentences. No personified sentences were made by the children at baseline, but personification quickly developed and increased in response to modeling and reinforcement. In this experiment generalization to new words occurred. In both experiments personification decreased to levels approaching baseline when nonpersonified sentences were presented to the children.

In another study, published in 1973, third graders wrote short compositions in response to slide-projected pictures. Compositions were scored for the number of different parts of speech employed, and independent judges rated the compositions for creativity. Praise and free time were used to reinforce increases in the frequency of word usage. Word-usage scores remained fairly stable during baseline but increased in response to reinforcement, and when the use of action verbs was reinforced, compositions were judged to be highly creative.

A different type of study was conducted with eight fourth and fifth graders by John Glover and A. L. Gary in 1976. Creativity was defined in terms of four dimensions of behavior: *fluency* (the number of ideas produced), *flexibility* (the variety of ideas produced), *elaboration* (the expansion of ideas produced), and *originality* (the statistical uncommonness of the ideas produced). Subjects were taught these criteria and given early recess and snacks for meeting these criteria in lists they generated to describe different possible uses for an item. Following instruction and reinforcement, these criteria were met substantially more than during a baseline period. Scores on the Torrance Test of Creative Thinking also increased significantly as a result of the instruction and reinforcement.

In a related study by John A. Campbell and Jerry Willis, instruction and reinforcement were combined in a multiple-baseline design to increase fluency, flexibility, and elaboration in the written compositions of 32 fifth graders. Following a baseline period, elaboration of ideas was reinforced with tokens and praise in ten daily writing sessions. In ten subsequent sessions, elaboration and flexibility were reinforced, and in the

final ten sessions, elaboration, flexibility, and fluency were reinforced. Children's scores in the three areas improved in response to specific reinforcement requirements; in other words, when only elaboration was reinforced, flexibility and fluency did not increase. Scores on the Torrance Test of Creative Thinking also improved.

Reinforcement was also shown to increase the creativity of lists of applications of psychological concepts made by 31 high school students. The students were required to write one paper per week on a topic related to psychology. The last section of each paper consisted of a list of all the different ways the psychological concept could be applied. During baseline (the first three papers) all of the students received feedback that their applications lists were "good." At the end of the third week the scoring criteria for creativity were explained and the students were told that they would receive extra credit for creative responding. As a result, students' scores in the four areas being measured (fluency, flexibility, elaboration, and originality) increased. Scores on the Torrance Thinking Creatively with Words Test also increased.

The writing of college students can also become more creative in response to reinforcement and instruction. This was demonstrated in a study by John Glover in which 14 undergraduates were taught the four behavioral dimensions of creativity and awarded class points for applying these principles to making lists of unusual ways to use randomly selected items and to solve everyday problems. Class papers were rated for creativity, and the Torrance Test of Thinking Creatively with Words was administered at the onset and conclusion of the study, as well as 11 months after the study ended. Fluency, flexibility, and originality increased in response to instructions and reinforcement. What's more, scores on the Torrance Test increased significantly from pre- to post-treatment conditions, and this increase was maintained in the follow-up test. The experimental group's scores were also significantly higher at posttest than the scores of a control group.

Reinforcement has also been used to promote creativity in the business world. For example, a 1991 study by Julie M. Smith and her colleagues increased the number of innovations made by employees of a public utility company. The company had been relying on a suggestion box to collect ideas from employees, but this method had a poor yield—an average of only 38 ideas per year had been collected over the previous 10 years. A system was introduced in which cash rewards were given for clearly defined types of suggestions. A rating system was devised to assess the potential benefit of each suggestion, and cash awards were made accordingly. In the first 9 months after this new program was instituted, 65 employees submitted a total of 89 suggestions, 12 of which were implemented.

A very different line of research suggests that reinforcement may be detrimental to creativity—and even, perhaps, to performance in general. Studies conducted in the 1970s showed that people who have been rewarded for engaging in an activity engage in that activity less often following reinforcement than they did before reinforcement—a phenomenon called the overjustification effect. A 1977 review of the relevant literature suggested also that reinforcement produces behavior that is repetitive and uncreative and that reward can interfere with people's problem-solving abilities. In a 1979 study and subsequent research, Teresa Amabile showed that reinforcement and "external evaluation" can interfere with artistic creativity. People who have been rewarded for behaving in certain ways can become dependent on that reward, performing poorly when reward is unavailable.

A meta-analysis of studies purporting to show various detrimental effects of reward, published by Robert Eisenberger and Judy Cameron in 1996, concluded that reward has negative effects under limited conditions that are easy to avoid. Negative effects typically attributed to reinforcement are actually produced by certain reinforcement *procedures,* not by reinforcement in the broad sense. For example, shifting from high-reinforcement to low-reinforcement conditions is easily detected and ultimately leads to low rates of responding in the low-reinforcement situation. Reinforcing specific properties of behavior—a certain type of brush stroke, for example—results in the repetition of those properties. Presenting too many reinforcers—a phenomenon called "satiation"—lowers the effectiveness of reinforcement. Using a large, salient reward that's present during a learning session is distracting, as anyone knows who has tried to train a dog while holding a piece of steak.

Generally speaking, reinforcement seems to interfere with creativity only it is used inappropriately. For

example, in a 1988 study by B. A. Hennessey and Teresa Amabile, children completed a painting task before constructing collages. Those children who were praised for their paintings—*irrespective of the quality of their work*—made subsequent collages that were less creative than those produced by children who were not praised for painting. It is not surprising that when trivial properties of behavior are reinforced, trivial behavior results, but it is also clear that reinforcement can be used to encourage novel and useful behavior—the behavior most people call creative. [*See* MOTIVATION/DRIVE.]

III. OTHER BEHAVIORAL METHODS FOR PROMOTING CREATIVITY

Reinforcement is often supplemented with other behavior-change methods, such as modeling and instruction. The latter two methods, along with various sorts of environmental manipulation, component-skills training, self-management training, goal setting, and problem-solving training, have been shown to foster creativity in a variety of settings.

Many authors who do not adopt behavioral methods or terminology per se have long recommended various changes in the physical and social environment—sometimes called climate or culture changes—to foster creativity. For example, in a 1987 article about boosting creativity in the workplace, Bruce G. Whiting suggested methods like "allowing people room" (reducing the level of supervision), "using diverse groups" (providing diverse social stimuli), and "information exchange" (giving people materials that describe activities in other parts of the organization). Others speak of creating a "nurturing" environment (one in which negative feedback is minimized), providing "socio-emotional support" (praise and other positive feedback for creative behavior), providing "task support" (stimulating work materials), and providing "incentives" (rewards for creative behavior). Many of these suggestions are vague, unfortunately, and their effectiveness may be unsupported by data. [*See* CONDITIONS AND SETTINGS/ENVIRONMENT.]

A Turkish study published in 1993 proposed that creativity in children can be stifled by cultural demands for discipline and conformity. One hundred ninety-two children in the third and fourth grades were rated using the Torrance Test of Creative Thinking and the Teacher Perception Scale (a measure of divergent thought and classroom nonconformity developed for this study), and, indeed, a significant correlation was found between creativity and nonconformity. Because this is a correlational study, however, it does not necessarily demonstrate that experience or the current environment stifles creativity. It may simply be the case that nonconformists are creative. [*See* CONFORMITY.]

Expectation by teachers or supervisors is another environmental factor that has been said to influence creativity. For example, Robert Rosenthal and colleagues found that when teachers were told that randomly selected children would make significant increases in creativity during the upcoming school year, those children showed significant gains in creativity as assessed by scores assigned to their drawings by a panel of eight professional artists. The teachers were observed to interact more often and in a slightly more *negative* manner with the children identified as having creative potential, but the precise nature of the interaction was not specified.

Component skills training is another method sometimes used by behavioral psychologists to promote creativity. Kent Johnson and T. V. Layng have described programs in which component skills—for example, basic arithmetic skills—are learned to "fluency," which means that the behavior must be swift and must be recur quickly after periods of disuse. Fluency in components of a complex repertoire results in the emergence the complete repertoire without the need for additional training. For example, fluency in arithmetic skills gave rise almost immediately to the ability to solve real-world story problems—novel behavior of the sort some would call creative. Learning-disabled children taught using this method advance on the average at the rate of 2 to 3 school years per year of instruction, and adults initially performing at the eighth-grade level gain almost 2 years on the average per 20 hours of instruction. Other studies have also shown that teaching component behaviors can be helpful in getting behavioral repertoires to generalize to new settings.

Self-management training—the deliberate use of behavioral technique for changing one's own behavior—can also foster creativity. John Glover has outlined a nine-step model for modifying one's own behavior in which the goal is to emit behavior that is especially flu-

ent, flexible, elaborate, and original. Glover recommends keeping records of behavior, setting goals, arranging consequences, and other self-management techniques. A 1989 study by Dennis Duchon has shown that goal setting alone can boost ideational creativity.

Self-management training has also been shown to promote problem-solving skills. In a study of two developmentally disabled adults employed at a community work site, the subjects were trained to use a four-step self-instructional method to solve problems and to reward themselves for doing so. Their ability to solve novel work-related problems independently increased dramatically as a result of training, and this ability was maintained over a 6-month follow-up period.

A 1989 study by Ellen Langer and her colleagues examined the effect of instructions on creativity with fourth graders, high school students, and college undergraduates. When information was presented in less-than-absolute terms, learners were more likely to use that information in creative ways. A statement like "a meta-poem uses rhyming words" produced writing that was less creative than that produced by a statement like "a meta-poem *could* use rhyming words." Apparently instructions that set boundaries on behavior—even by implication—can stifle creativity.

In a related study, instructions given to three groups of normal adults trying to solve a conceptual problem were varied. Group 1 was warned about various emotional and conceptual blocks to problem solving at the onset of the 30-minute session. Group 2 received similar instructions at the beginning of the session and also halfway through the session, and Group 3 received similar instructions every 5 minutes during the session. On the average, subjects in the second group performed far better than subjects in the other two groups, which suggests that instructions can assist in problem solving as long as the instructions are not excessive.

Other studies have suggested that prompts and modeling can increase the number of creative behaviors children emit.

Some behavioral psychologists teach problem-solving strategies in order to enhance an individual's ability to generate and test novel solutions to novel problems; because such behavior is both novel and useful, it satisfies a common definition of creativity. According to one report, the major components of this type of training include: (a) problem identification, (b) goal definition, (c) generation of alternatives, (d) comparison of consequences, and (e) selection of the best solution. Eight adolescent boys who had been diagnosed with conduct disorder showed improved problem-solving ability when taught these skills. Three of the boys were able to apply their new skills to problem social situations outside the training setting.

IV. MEASURING CREATIVE BEHAVIOR

Behavioral psychologists concerned with creativity tend to focus on creative behavior per se rather than on creative ability or creativity as a personality trait. Under what conditions does such behavior occur, how can such behavior be defined, and how can we detect and measure such behavior? These are the basic questions.

Unfortunately, there is no consensus among behavioral psychologists (or, for that matter, among other professionals) about how to define and measure creative behavior. The problem stems from the fact that the language of creativity is part of the vernacular; it is imprecise and employed inconsistently. Typically, behavior or the product of behavior is judged to be creative only if it has value for some community, and this makes the language of creativity especially capricious. For example, a painting considered creative by one community—say, the squiggly lines of Jackson Pollock—would be considered trash by another, and, to make matters worse, these judgments change over time.

Howard Sloane and his colleagues have suggested that it is neither the behavior nor the product of behavior that leads to the judgment of creativity. Rather, we call behavior "creative" when behavior is controlled by nonobvious multiple stimuli—in other words, when it is difficult to discern all of the controlling sources of the behavior. Arguing against this view is the fact that people often label highly unusual products creative (for example, the moveable art of Alexander Calder or Einstein's theory of relativity) based on properties of the products alone. Moreover, virtually all behavior is controlled by multiple, nonobvious stimuli, yet very little behavior is considered creative.

To simulate the judgment of the community, researchers often rely on independent judges, supervisors, teachers, or colleagues to determine whether be-

havior or its products are creative. In the Rosenthal study mentioned above, for example, eight professional artists—two musicians, two writers, a graphic artist, a dancer, a photographer, and a singer—scored children's drawings for creativity. But Goetz rejected the use of judges as unscientific and subjective. In her research, she typically predefined categories of novel forms she expected to find (in block building, painting, and collage making) and then tabulated occurrences in each of the categories. The judgment of judges, said Goetz, is "fickle" and "idiosyncratic." The studies by Glover and his colleagues also tended to use relatively objective measures of creativity (e.g., word counts indicating fluency, flexibility, elaboration, and originality) rather than relying on the subjective judgments of independent judges.

In the organizational setting, creativity is sometimes measured by counts of suggestions placed in suggestion boxes, number of patents applied for or issued, or number of publications. An ambitious study published in 1960 by William Buel sought to validate a behavioral rating scale of individual creativity at an oil company. Buel had supervisors give behavioral descriptions of their most and least creative employees. A selection of these statements was compiled into an assessment checklist, which was then use to rate other employees. Other supervisors, in turn, rated the creativity of those employees. Statistical analyses of the scores and rankings led to the selection of items that seemed to predict creativity best. Only modest correlations were found, however, between test scores and various objective measures of creativity, such as patent submissions.

V. GENERATIVE ASPECTS OF BEHAVIOR

Behaviorism, a philosophical doctrine developed by John B. Watson, B. F. Skinner, and others, suggested that people lack an inner, initiating self or agent. An organism, said Skinner, is simply a locus through which its genes and experience act to produce behavior. An organism is not responsible for its actions, and, although it may behave in novel ways, in no sense could it be said to *initiate* action, creative or noncreative.

Two things can be said about this viewpoint. First, although behaviorism helped drive behavioral research in the first half of the 20th century, most researchers who study behavior today do so without any guidance from behaviorism. Behavior is a legitimate subject matter for science, and it is possible to study behavior without being constrained by any particular philosophical doctrine. Second, whether an initiating agent exists or not, it is clear that virtually all behavior is *generative,* meaning that behavior continuously varies in novel ways. Sometimes the variations are trivial, and sometimes they are significant—so significant that the community calls them "creative."

In recent years researchers have looked at several generative aspects of behavior. Stimulated by a paper published by Murray Sidman in 1971, scores of studies have now been performed that examine a phenomenon called "stimulus equivalence": When someone is taught the relationship between Stimulus A and Stimulus B (e.g., the written word *cat* and a picture of a cat) and is also taught the relationship between Stimulus B and Stimulus C (e.g., a picture of a cat and an arbitrary symbol), a relationship between A and C may emerge spontaneously (e.g., the person may now be able to pair the word *cat* with the symbol). Equivalence relations of various sorts have been identified and studied. Because these relations are not specifically instructed or reinforced, their appearance is considered to be generative. Equivalence relations have been shown to emerge in animal behavior, but they are particularly common in human language.

A report published in 1993 extended the concept of stimulus equivalence to sequences of as many as five stimuli. In experiments with college students and children, a computer touch screen was used to teach subjects to select five symbols in a particular sequence (e.g., A1-A2-A3-A4-A5). When the sequence was mastered, test trials showed that many subjects also had learned the relationship between both adjacent (e.g., A2-A3) and non-adjacent (e.g., A1-A3) pairs of symbols. Even more striking, when subjects were taught two different sequences (e.g., A1-A2-A3-A4-A5 and B1-B2-B3-B4-B5), some subjects also learned the relationship between ordered pairs in different sequences (e.g., A1-B3 and B2-A4).

Organisms also have a tendency to manipulate objects in creative sequences. Both human and animal infants engage in combinatory play, behavior that seems essential to the emergence of tool use and other cre-

ative behaviors. A 1993 report by G. C. Westergaard describes combinatory play in baboons as young as 2 months of age. When given simple objects (a ball, a rod, and a bowl), three out of four of the baboon infants observed spent more than half of each 15-minute session picking up the objects in pairs and touching them against each other in various ways. By the time the infants were six-months old, they were able to use one or more of the objects as tools. In a 1945 investigation of problem solving, six young chimpanzees that had never had the opportunity to handle sticks could not use sticks to retrieve objects beyond their reach. When sticks were placed in their cages, however, each chimp handled the sticks spontaneously. After just three days of stick play, each of the chimps was able to solve a variety of novel problems. These and related studies on problem solving and tool use suggest the existence of two generative behavioral processes: combinatorial play and spontaneous problem solving.

Problem-solving behavior is necessarily both novel and useful, at least to the organism. Because a particular problem-solving performance may not be useful to the community (for example, when a child first climbs on an object to extend his or her reach), the community might not label the behavior creative, but the distinction is trivial. In any case, a century of research on problem solving in both animals and people, beginning with the work of Edward Thorndike, has revealed a variety of determinants of this important category of generative behavior. [*See* PROBLEM SOLVING.]

Behavioral theories of problem solving have typically characterized it as an interconnection or integration of previously established behaviors. For example, in 1955 Irving Maltzman proposed a behavioristic theory of problem solving inspired by the work of Clark Hull. According to Maltzman, problem solving was the result of "combinations and recombinations" of "habit strengths" (the strength of the relationship between a stimulus and a response). Hull himself proposed a similar theory in 1935, but neither Hull's nor Maltzman's approach allowed specific predictions to be made. A formal, predictive theory of creativity and problem solving, called Generativity Theory, was proposed by Epstein in the mid-1980s. As in earlier theories, Generativity Theory suggests that new behavior emerges from the interconnection of old behaviors; however, this approach uses equations and computer-modeling techniques to predict novel performances in the laboratory continuously in time, and it has also been used to engineer novel performances in both animals and people.

VI. CONCLUSIONS

Behavioral psychology, the branch of psychology that focuses on behavior rather than cognition, has shed light on several aspects of the creative process, both from a practical perspective and a theoretical perspective. On the practical side, behavioral psychologists have shown that a variety of techniques can spur creativity, including reinforcement, instructions, modeling, self-management training, environmental manipulation, component-skills training, generalization training, goal setting, and problem-solving training. On the theoretical side, behavioral psychologists have developed both informal and formal models of the creative process, most of which view creativity as the result of an interconnection or integration of previously established behaviors.

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